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A Study on the Split Tensile Strength of Fiber Reinforced Concrete subjected to Sustained Elevated Temperature

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ABSTRACT

The aim of this Study is to determine the residual Split Tensile Strength after exposure to elevated temperature of plain and fiber reinforced concrete in comparison with specimens exposed to ordinary room temperature. Fiber reinforced concrete with polypropylene (PPFRC) and steel fiber (SFRC) of varying percentage of (0.05, 0.10&0.15) & (0.5, 1 &1.5) respectively were adopted for concrete mix M20, M25 & M30. To study splitting tensile strength a total of 630 cylinders of 150mm diameter and 300mm length were casted. After specified period of curing, specimens were air dried and then exposed to 100,200 &300°c for the exposure duration of 2, 4&6hrs and then allowed to cool. Cylinders are tested for split in compression testing machine. Result shows that addition of fibers both polypropylene and steel improves split tensile strength for specimens without heating. For PPF (0.05, 0.1&0.15) the percentage of reduction in splitting tensile strength is lower than that of PC (without fiber) after exposure to a temperature (100,200&300°c).While specimen containing steel fiber (0.5, 1&1.5) improves split tensile strength up to increase in temperature to 100°c for exposure period of 2hrs.Result shows that the loss in splitting tensile strength for SFRC is appreciable lower in comparison with that plain and polypropylene concrete for all tested temperature. Optimum steel fiber content of 1% has superior behavior up to rise in temperature to 100°c for exposure period of 2hrs.Decrease in split tensile strength observed for PC, PPFRC &SFRC volume fraction of fiber after exposure to temperature of 300°c.

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INTRODUCTION

Fiber reinforced concrete is relatively a new construction material developed through extensive research and development work during the two decades. Many studies on the degradation of concrete when it is exposed to rise in temperatures have been reported. It has already found a wide range of practical applications and proved to be a reliable construction material having superior performance characteristics compared to conventional concrete. Concrete is good in compression but week in tension, high temperatures induces high temperature gradients, which intern induces high tensile stresses. Concrete structures may be exposed to temperature rise, by accidental causes or by the characteristics of the structural application. As a consequence, concrete undergoes changes that may result, in many cases, in extensive cracking. In this sense, it is interesting to study the contribution of fibers to control crack formation and propagation. The mechanical properties of fiber reinforced concrete (FRC) after high temperatures have received considerable attention in recent years. Plain concrete is not capable of resisting these tensile stresses. Due to its low tensile strength, micro cracks propagate leading to brittle fracture of concrete. The low resistance to crack propagation results in a fracture toughness and limited resistance to impact and explosive saplings. When concrete is exposed to high temperatures the free water evaporates and above 150^0c the chemically bound water is released from the hydrated calcium silicate, this process reaches its peak at 270^0c.The dehydration of the matrix and the thermal expansion of aggregate give rise to internal stresses. The tensile strength of concrete can be increased by introducing reinforcing bars or by pre stressing methods but, inherent tensile strength property of concrete is not increased. Addition of fibers helps in increasing the inherent tensile strength of concrete. concrete which contains cement, sand, aggregate and discontinuous discrete fibers is called

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fiber reinforced concrete(FRC).Fiber present in the concrete act as bridge and helps in arresting cracks ,static and dynamic properties of matrix Incorporation of fiber in concrete has found to improve several properties like tensile strength, cracking resistance, impact and wear resistance, ductility and fatigue resistance. Fibers that can be used in engineering construction are asbestos, steel, polypropylene, nylon, coir, glass and carbon. Polypropylene melts at 165^0c and has no advantage as reinforcing materials as temperature rises. Use of polypropylene fiber enhances the performance with respect to tensile and flexural strength through bridging mechanism of PPF. Steel fibers are one of the most widely used fibers in concrete. They are available in different shapes and sizes as crimped, flat, hooked etc .Increase in fiber volume fraction will increase the tensile strength. There is not much information on optimum fiber content for both polypropylene and steel fiber, hence volume fraction of 0, 0.05, 0.1 &0.15% and 0.5,1,& 1.5% were adopted in present test. Little investigation has been noticed to provide experimental results about the effect of fibers on properties of concrete at elevated temperature. This paper indents to contribute to the understanding of concrete behavior at elevated temperature. Steel fiber volume of 1% into concrete is extremely effective in improving tensile strength of concrete at elevated temperature. Mix with steel fiber concrete performed better than mix without steel fiber. The properties that are known to control FRC behavior at elevated temperatures are compressive strength, tensile strength, peak strain, modulus of elasticity, flexural tensile strength and others that are non-liner functions of temperature. Many compressive and tensile constitutive models for concrete at normal temperature are available. The constitutive laws of concrete materials under fire conditions are complicated and current knowledge of thermal properties is based on the outcome of limited experimental tests of materials properties. This paper proposes reliable constructive relationships for PPFRC and SRC for fire –resistance predictions of RC members.

Objectives:

1. To study the effect of sustained elevated temperature ranging 100^0c to 300^0c for the exposure period of 2, 4, 6 hrs for M20, M25 and M30 grade concrete with and without steel and polypropylene fiber with reference to tensile strength.
2. To compare the results obtained at room temperature (unheated), with and without steel and polypropylene fiber.

Polypropylene fiber reinforced concrete (PPFRC):

The addition of polypropylene fiber is at recommended dosage of approximately 0.90kg/m³ (0.1% by volume) (Knapton, 2003), the fiber volume is so low that mixing techniques require little or no modification from normal practice (Newman *et al*, 2003).This fiber may be added at either a conventional batching/mixing plant or by hand to the ready mix truck on site (Knapton , 2003).Concrete mixes containing polypropylene fibers can be transported by normal methods and flow easily from the hopper out let. No special precautions are necessary. Conventional means of tamping or vibration to provide the necessary compaction can be used. Curing procedures similar to those specified for conventional concrete should be strictly undertaken. Specimens are immersed into water for the specified period of 28 days. Polypropylene fiber act mechanically, they impart a cohesive effect by holding water at or near the fiber surface of the concrete, delaying evaporation and increasing cement hydration (Knaption,2003).The slump of fiber-dosed concrete is not significantly affected by the addition of polypropylene fibers.

Steel fiber reinforced concrete (SFRC):

Compared to plain concrete, fiber reinforced concrete mixes generally have higher cement and fine contents and smaller aggregates. The slump decreases as the fiber content increases (Newman *et al* ,2003;ACI Committee 544.1R,1996).In order to obtain steel fiber-reinforced concrete that is easy to work with minimum shrinkage, manufactures should specifies the following (Bekaert,1990) Quantity of cement should be between 350 kg/m³ and 450kg/m³

- 750-850 kg/m³ well graded fine aggregate
- Characteristic compressive strength at least 20 N/mm²
- W/C ratio not to exceed 0.5
- Use of super plasticizer is permitted to obtain the necessary workability

The recommended dosage rate of steel fiber is usually between 20 and 40kg/m³.The greater the dosage rate the greater is the flexural strength of concrete (Knapton, 2003).Generally the fibers are added last to the fresh concrete, care being taken to ensure that no clumps are added and the fibers are rapidly moved from the entry point to the mixture. As long as the aspect ratio of the fiber is less than 50, the fibers may be dispended directly without any risk of balling. Visual inspection is necessary to check the fiber distribution. The inclusion of the fibers into the concrete mix influence its workability (Hannat,1978;Swamy,1974) ACI committee report in 1996,reported that in the typical ranges of volume fractions used for steel fiber reinforced concrete (0.25 to 1.5 volume present),the addition of steel fiber reduced the measured slump of the composite as compared to plain concrete in the range of 25 to 102mm.Incorporation of super plasticizer is essential to maintain good workability(120-150mm). Steel fiber improves the ductility of concrete under all modes of loading. But their effectiveness in improving strength varies among compression, tension, shear, torsion and flexure. Steel fiber concrete is more durable than plain concrete.

Scope of present Investigation:

The purpose of present study was to compare the mechanical properties of Plain concrete (PC), Polypropylene fiber reinforced concrete (PPFRC) and Steel fiber reinforced concrete (SFRC).Parameter studied is split tensile strength.

Research significance:

Concrete structures may be exposed to elevated temperatures at which deterioration of concrete occurs and it leads to deterioration of Compressive strength, tensile strength, Split tensile strength, modulus of elasticity and impact strength. Little investigation have been noticed to provide experimental results about the effect of PPF&SF on the properties of concrete at elevated temperature, so it becomes necessary to make additional studies on the effect of elevated temperature on properties of fiber reinforced concrete with polypropylene and steel fiber. In this study an investigation is carried out on the effect of elevated temperature on the tensile strength. Three compositions of concrete are presented in this paper one without fiber (PC), one with Polypropylene fiber (PPFRC) and another with steel fiber (SFRC).Some variables being focused on concerning effect of fiber on concrete residual properties including fiber volume (VF), fiber length (lf) and fiber materials. For each type of concrete mix (M1, M2&M3) three sets of specimens of cubes for standard concrete, PPFRC and SFRC with VF of (0.05,0.1 &0.15%) and (0.5, 1&1.5%.). Each set contains 9 specimens and total of 630 cube specimens of standard concrete, PPFRC and SFRC have been cast out. All the specimens were exposed to 100^{0}c, 200^{0}c &300^{0}c for sustained exposure period of 2hrs, 4hrs & 6hrs.All the heated specimens were cooled to room temperature .One set of unheated specimens of all mixes with and without fiber content and all other heated specimens cooled to room temperature were tested for its split tensile strength. The results were analysed and final conclusion drawn

Material & Mix proportion** 1. **Materials:

Cement used in concrete mixture was ordinary Portland cement of 53 grade, fine aggregate was natural river sand conforming to Zone II of IS 383:1970 with the maximum size of less than 4.75mm.Coarse aggregate satisfies gradation in table 2 of IS 383:1970 with aggregate of size 20mm down was used .Two types of fibers were used for present investigation (i) Hooked steel fiber and (ii) Polypropylene fibers. The properties of hooked steel fiber and Polypropylene fibers are listed in Table.

Table 1: Steel fiber specification

Fiber type	Density (kg/m3)	Ultimate tensile strength (MPa)	Modulus of elasticity (MPa)	Poisons ratio	Length (mm)	Nominal diameter (mm)
Hooked steel fiber	7860	1130	200000	0.28	25	0.5

Table 2: Physical Properties of Polypropylene fiber (PPF) used

Form	Specific gravity	Alkaline, Chloride & Sulphate content	Fiber thick	Young’s Modulus	Tensile strength	Melting point	Fiber length
Virgin Polypropylene	0.91	nil	182 30 microns	5500-7000 MPa	350 MPa	160^{0} C	19mm

Mix proportion:

Three types of concrete with three different mix proportions of M1, M2, &M2 were prepared using different water cement ratios ranging 0.45-0.5(i) Plain concrete (ii) Concrete reinforced with Polypropylene of VF 0.05, 0.1&0.15% (iii) Concrete reinforced with Steel fiber of VF 0.5, 1&1.5%.The literature shows that the strength of concrete mix dependent on the variation in proportions of constituent materials. Considering this aspect the experiments have been planned to study the variation in strength properties with three different mixes when subjected to elevated temperature. Mix proportions (M) M1=1:1.85:3.25,w/c=0.5,M2=1:1.6:3.06,w/c=0.48,M3=1:1.6:2.8,w/c=0.45 by weight of dry materials have been considered for the investigation. Concrete composition design is given in table. Percentage of fibers is decided based on the literature review. To maintain proper workability required quantity of Super Plasticizer namely CERAPLAST added into concrete particularly when steel fiber added into concrete. Mix design of conventional plain concrete mix (PC) is carried out according to IS 10269: 2009.

Concrete mix M20 (M1)

w/c ratio	Water	Cement	FA	CA	Chemical Admixture
0.50	186.5 lit/m³	373 kg/m³	680 kg/m³	1172 kg/m³	3.25 kg/m³

Concrete mix M25 (M2)

w/c ratio	Water	Cement	FA	CA	Chemical Admixture
0.48	185 lit/m³	385 kg/m³	710 kg/m³	1181 kg/m³	3.50 kg/m³

Concrete mix M30 (M3)

w/c ratio	Water	Cement	FA	CA	Chemical Admixture
0.45	191 lit/m³	425 kg/m³	696 kg/m³	1198 kg/m³	3.75 kg/m³

Scope of present Investigation:

Considering the objectives, the following studies have been planned to know the effect of sustained elevated temperature on plain concrete (PC), Polypropylene fiber reinforced concrete (PFRC) and Steel fiber reinforced concrete (SFRC).

Studies on the structural properties of concrete such as Split Tensile strength

1. To study all the above characteristics the experiments have been planned using,

a. Different type of mixes
b. Different levels of temperature
c. Different exposure durations
d. Different volume fraction of Polypropylene fiber into concrete
e. Different volume fraction of Steel fiber into concrete

By adopting unstressed residual strength tests.

Test methods:

The specimens are heated slowly to a target temperature, the external temperature is held constant to allow the internal specimen temperature to reach uniform value. The properties are measured after a uniform internal temperature is reached. The specimen is then allowed to cool to room temperature. Load is applied at room temperature until the specimen fails. The result obtained is most suitable for assessing the post fire (residual) properties of concrete. The slump test for three types of concrete mixes was performed with targeted slump flow of 100mm.Following residual mechanical properties were determined at the age of 28 days curing. Testing for split tensile strength of concrete is done as per IS 5816-1959.The test is conducted on Compression testing machine of capacity 3000KN .The cylinder is placed horizontally between the loading surfaces of compression testing machine and the load is applied till failure of cylinder. Packing material such as plywood is used to avoid any sudden loading. During the test the platens of the testing machine should not be allowed to rotate in a plane perpendicular to the axis of cylinder.

Split tensile strength = 2P / π LD:

Where P = load at failure, L=length of the cylinder and D = diameter of the cylinder

The test results of PPFRC and SFRC are compared with plain concrete (PC).

Heating Equipment:

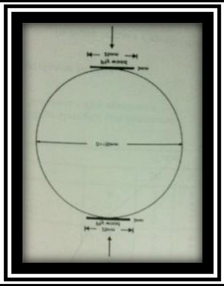
Three ovens have been used to conduct the experiments. The oven capable of reaching a maximum temperature of 300^{0}c had storage of 1.2m X1.1mX and .95m.Electric power used to raise the temperature inside the oven. The standard specimen of cylinder of size 150 X 300 mm were cast to determine the split tensile strength of concrete at 28 days and test were performed according to IS: 5816.Casted specimens were de molded after 24 hrs and cured under water for the period of 28 days. After 28 days of curing, the specimens were prepared for testing at room temperature and at elevated temperature.

Procedure for casting and Heating of specimens:

All the specimens were cast in steel mould. After 24 hours of casting they were de molded and placed in a curing tank for 28 days. The specimens were removed and air cured for one day in room temperature till they were taken for experimentation. These specimens were kept inside the oven and required temperature of 100^{0}c or 200^{0}cor 300^{0}c was set. Specimens were kept inside the oven for varying time between 2hrs and 6hours.After the steady state reached the specimens were sustained for predetermined duration of time 2hrs or 4hrs or 6hrs at the end of which the specimens were cooled to room temperature and tested for their residual characteristics using proper experimental set up.







RESULT AND DISCUSSION

For all the concrete mixes M1, M2& M3 for plain concrete (PC), Polypropylene fiber reinforced concrete (PPFRC) and Steel fiber reinforced concrete (SFRC) exhibits tensile strength loss as temperature increases. For plain concrete it was observed that increase in tensile strength up to 200^0c for 2 & 4hrs exposure period and further increase in temperature above 200^0c and exposure period of 6hrs cause considerable decrease in tensile strength. The tensile strength of concrete specimens containing fiber (PPF&SF) for all temperature shows higher strength as compared to concrete specimens without fibers. As fiber bridges the cracks and control crack width. Hence increase the load carrying capacity and strength.PPF with VF of 0.05, 0.1&0.15% offers improved tensile strength for all tested temperature than plain concrete. But considerable decrease in tensile strength was observed for PPF with VF of 1.5% starting from room temperature 100^0c, 200^0c & 300^0c for sustained exposure period of 2hrs, 4hrs&6hrs. Steel fiber with VF 0.5,1&1.5% offers considerable increase in tensile strength and residual tensile strength than PPRFC and plain concrete (PC) at all temperature levels. Optimum steel fiber content of 1% offers maximum increase in tensile strength of 38.90% for Mix M3 at 100^0C – 2hrs exposure.

Plain concrete (PC):

It is observed that residual strength of the mixes M1, M2&M3 subjected to air cooling has decreased as the temperature and duration of exposure are increased. Test result revels that maximum increase in residual split tensile strength of air cooled specimen of mix M1-17.25%, M2-20.25% & M3-26% observed at elevated temperature of 100^0c for 2 hrs exposure period. Further increase in temperature cause decrease in split tensile strength, at 200^0c for the exposure period of 6hrs there was decrease in residual strength of M1-13%; M2-17%&M3-22%.Test result shows that least reduction in residual tensile strength observed at 300^0c for the exposure period of 6hrs are M1-47%, M2-51%& M3-61%.

Polypropylene fiber reinforced concrete (PPFRC) with VF of 0.05, 0.1 & 0.15%:

Addition of PPF with VF 0.05,0. 1& 0.15% in Mix M1, M2& M3 increase the split tensile strength marginally. An increase in strength of 4%, 7%&9% observed for addition of 0.05% & decrease in strength observed for 0.1 and 0.15% (5, 8 &11.83%) and (7, 11&13%) respectively for the specimens without heating tested at room temperature. This is due to the fact that the presence of fibers increases stain ability in tensile failure and hence the tensile strength increases as represented by (Chali).Reduction in tensile strength observed when Specimens heated to temperature of 100^0c, 200^0c & 300^0c for the exposure period of 2hrs, 4hrs & 6hrs.It is noticed that reduction in tensile strength with respect to increases in temperature and time of exposure. At 100^0c loss in strength observed was marginal and there is considerable decrease in tensile strength as the temperature reaches 300^0c for the sustained period of 6hrs for the VF 0.05,0.1 &0.15%.This is due to loss of cement paste plasticity at high temperature, thus break down of inter facial bond between cement paste and aggregate during heating & cooling and de hydration of calcium hydroxide occurs when temperature reaches to 200^0 & Percentage of loss at maximum exposure 6hrs in tensile strength for mix M1,M2& M3 with VF of 0.05,0.1 &0.15% with respect to room temperature of plain concrete observed as (14%,17%&19%) (35%, 37%&38%) & (59%, 66%&73%) respectively. As per test result, maximum loss in tensile strength observed at 300^0c for exposure period of 6hrs and it varies 28-30% for VF of 0.05%& 54-56% for VF of 0.1% and it was observed huge loss of 98.5% -103% for volume fraction of 0.15%.This may be due to combined effect of the temperature which affects the micro structure of concrete and because of PPF its melting point (especially after 160^0c) which results in large week points between in gradients of concrete.

Steel fiber reinforced concrete (SFRC) with VF of 0.5, 1&1.5%:

Increase in tensile strength was observed on un heated specimen tested at room temperature with respect to standard specimen for the steel fiber volume fraction of 0.5,1&1.5% for mix M1,M2&M3 observed as (17.5%,18%&20%) (28%, 32%&34%) & (25%, 27%&28%). Maximum increase in tensile strength for tested specimen observed at 100^0c for exposure period of 6hrs with steel fiber content of 1% given as (40%, 42%&40%) for mix M1, M2&M3. Further increase in temperature up to 300^0c at 6hrs exposure period cause decrease in tensile strength comparing to unheated SFRC at room temperature for the VF of 0.5,1 & 1.5% was observed for mix M1,M2,&M3 given as (65,51&45%),(38,40&42%) and (95,90&56%). The investigation programme included the determination of optimum fiber content which can be provided in the concrete composites for different mix ratios. Optimum fiber content was determined based on tensile strength of the standard specimen. Test result revels that maximum increase in tensile strength was found 34% at room temperature and 42% for 100^0c at an exposure period of 6hrs with an optimum steel fiber content of 1%.Test result revels that maximum increase in tensile strength observed with addition of 1% of steel fiber into plain concrete at all temperature levels and tensile strength for addition of 1.5% of SF observed was comparatively lower than 1% of SF. Hence test result concludes 1% was Optimum steel fiber content. It was observed that SFRC exhibits more tensile strength than concrete without fiber at all the temperature. As the temperature is increased SFRC maintained low decrement profile than normal concrete resulting in more percentage compressive strength at 100^0c for 6hrs sustained exposure period.

Residual Split Tensile Strength of Plain & Polypropylene Fiber Reinforced Concrete

Temperature	Duration of exposure	Residual Split Tensile Strength N/mm²											
		Standard Specimen without Fiber			Polypropylene Fiber with different volume Fractions								
		0% Fiber			0.05%			0.1%			0.15%		
		f_{T1}	f_{T2}	f_{T3}	f_{T1}	f_{T2}	f_{T3}	f_{T1}	f_{T2}	f_{T3}	f_{T1}	f_{T2}	f_{T3}
Room Temperature	0 hrs	3.27	3.51	3.68	3.410	3.75	4.01	3.11	3.22	3.29	3.05	3.1	3.35
100^0C	2 hrs	3.84	4.22	4.34	3.40	3.61	3.91	3.09	3.11	3.16	2.95	3.0	3.13
	4hrs	3.613	3.68	3.89	3.241	3.445	3.714	2.979	3.065	3.095	2.86	2.95	3.05
	6 hrs	3.31	3.46	3.71	3.104	3.28	3.54	2.84	2.96	2.84	2.65	2.8	2.85
200^0C	2 hrs	3.61	3.73	3.64	3.100	3.21	3.47	2.67	2.89	2.83	2.41	2.55	2.61
	4 hrs	3.212	3.11	3.21	2.985	3.14	3.31	2.51	2.74	2.81	2.11	2.24	2.31
	6 hrs	2.896	2.99	3.00	2.875	3.00	3.14	2.41	2.56	2.71	2.05	2.11	2.11
300^0C	2 hrs	2.814	2.91	3.11	2.741	2.96	3.02	2.32	2.41	2.67	1.95	2.05	2.0
	4 hrs	2.541	2.41	2.74	2.621	2.81	2.99	2.15	2.31	2.54	1.85	1.95	1.99
	6 hrs	2.226	2.31	2.28	2.543	2.74	2.88	2.12	2.3	2.42	1.65	1.75	1.85

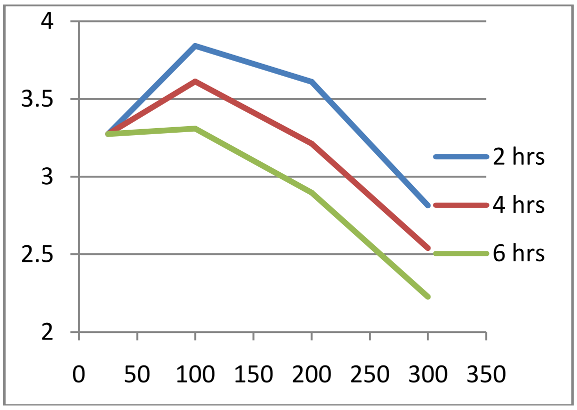
Residual Split Tensile Strength of Plain & Steel Fiber Reinforced Concrete

Temperature	Duration of exposure	Residual Split Tensile Strength N/mm²											
		Standard Specimen without Fiber			Steel Fiber with different volume Fractions								
		0% Fiber			0.5%			1%			1.5%		
		f_{T1}	f_{T2}	f_{T3}	f_{T1}	f_{T2}	f_{T3}	f_{T1}	f_{T2}	f_{T3}	f_{T1}	f_{T2}	f_{T3}
Room Temperature	0 hrs	3.275	3.51	3.68	3.85	4.10	4.25	4.21	4.65	4.85	4.1	4.37	4.62
	2 hrs	3.84	4.22	4.34	4.2	4.35	4.61	4.62	4.78	5.15	4.51	4.60	4.71

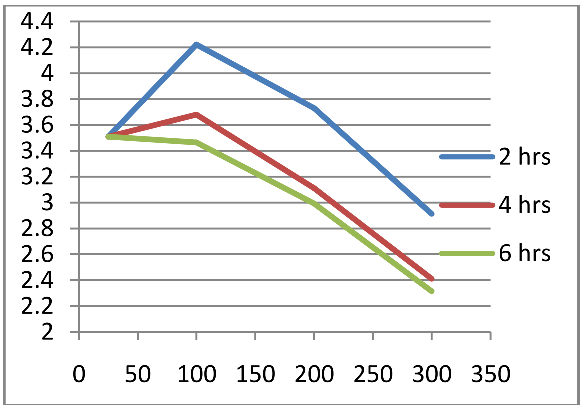
100^0C	4hrs	3.613	3.68	3.89	3.95	4.12	4.21	4.5	4.63	4.88	4.44	4.45	4.5
	6 hrs	3.31	3.46	3.71	3.85	3.85	3.95	4.25	4.13	4.67	4.00	4.1	4.31
200^0C	2 hrs	3.61	3.73	3.64	3.7	3.78	3.51	4.32	4.54	4.32	4.27	4.5	4.75
	4 hrs	3.212	3.11	3.21	3.34	3.53	3.22	3.87	4.13	4.38	4.05	4.24	4.42
	6 hrs	2.896	2.99	3.00	2.95	2.96	2.99	3.56	4.09	4.13	3.85	4.1	4.25
300^0C	2 hrs	2.814	2.91	3.11	2.85	3.11	3.36	3.85	4.01	4.17	3.65	3.86	4.05
	4 hrs	2.541	2.41	2.74	2.41	2.89	3.11	3.32	3.72	3.9	2.97	2.95	3.94
	6 hrs	2.226	2.31	2.28	2.32	2.75	2.92	3.06	3.33	3.42	2.10	2.3	2.95

Split tensile Strength of Plain Concrete (PC), Polypropylene Fiber Reinforced Concrete (PPRFC) &Steel Reinforced Fiber Reinforced Concrete (SRFC) for Different Volume Fraction, Temperature &Different Exposure

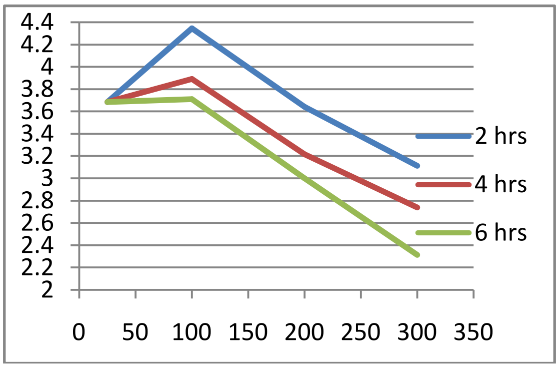
"Y" Axis – Split Tensile Strength-N/mm² (Vs) "X" Axis – Temperature -^{0}C:



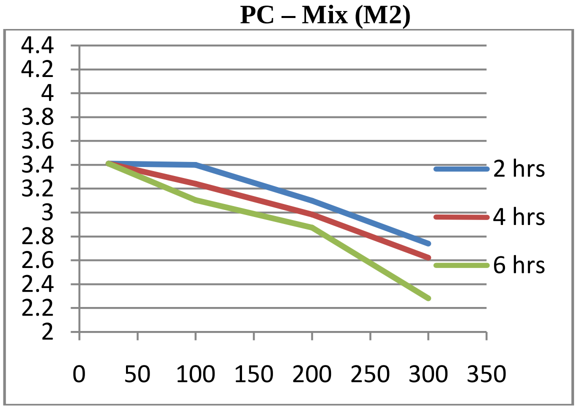
PC-Mix (M1)



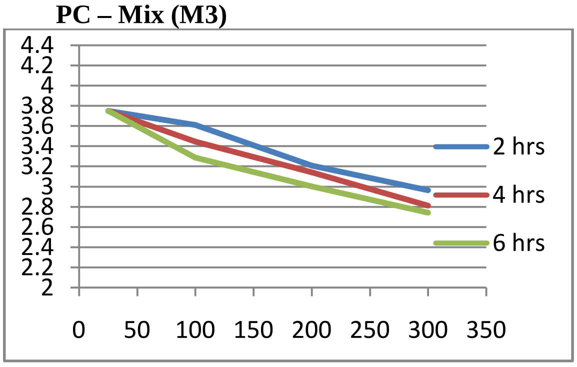
PC – Mix (M2)



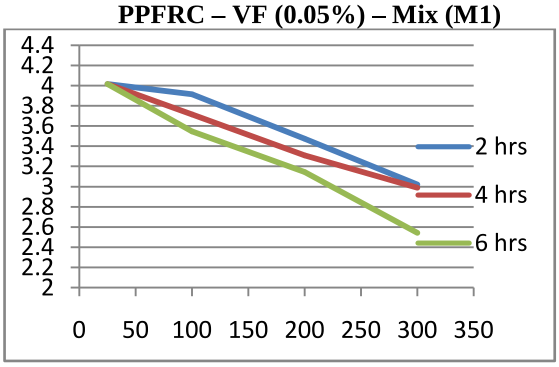
PC – Mix (M3)



PPFRC – VF (0.05%) – Mix (M1)



PPFRC – VF (0.05%) – Mix (M2)



PPFRC – VF (0.05%) – Mix (M3)

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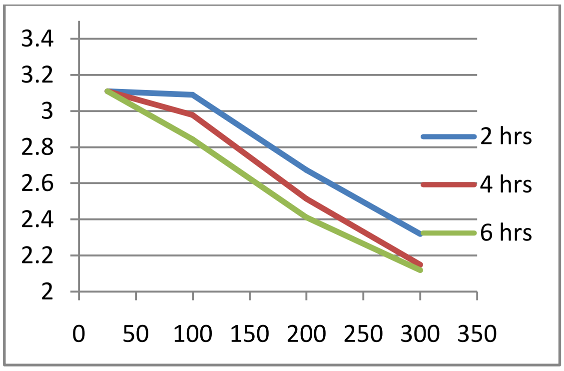
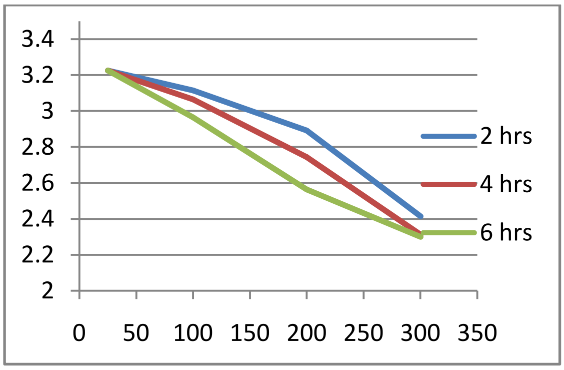
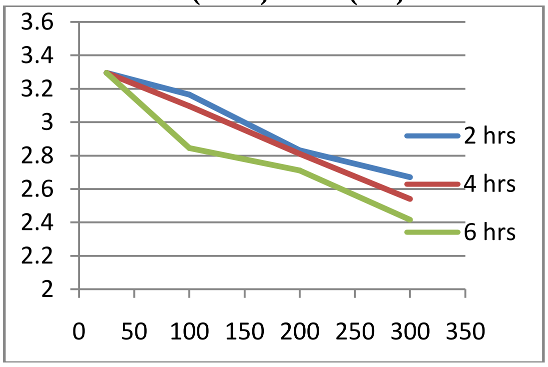


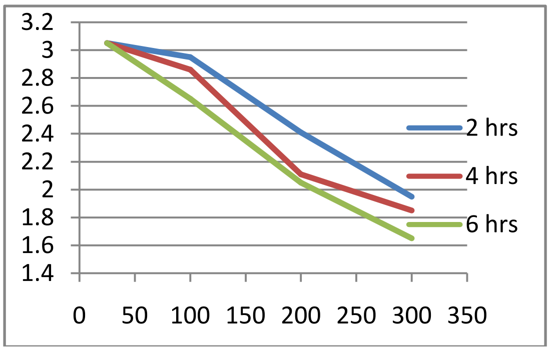
PPFRC – VF (0.1%) – Mix (M1)



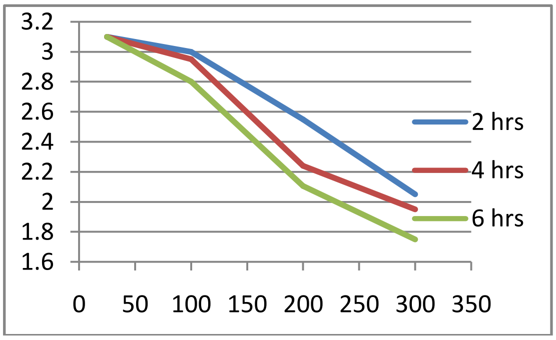
PPFRC – VF (0.1%) – Mix (M2)



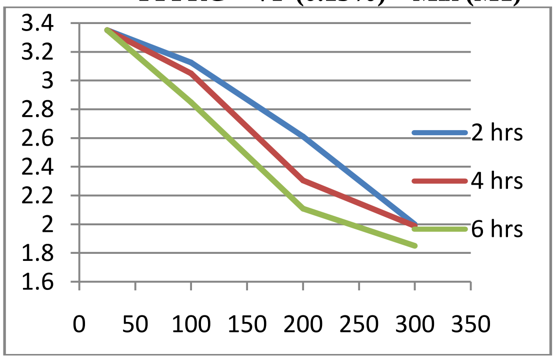
PPFRC – VF (0.1%) – Mix (M3)



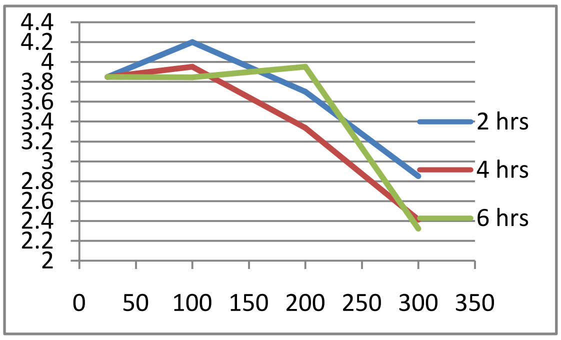
PPFRC – VF (0.15%) – Mix (M1)



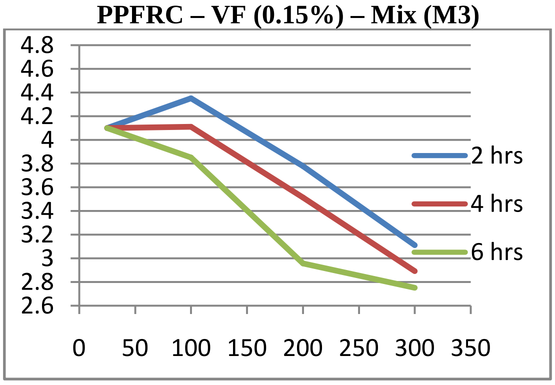
PPFRC – VF (0.15%) – Mix (M2)



PPFRC – VF (0.15%) – Mix (M3)



SFRC – VF (0.5%) – Mix (M1)



SFRC – VF (0.5%) – Mix (M2)

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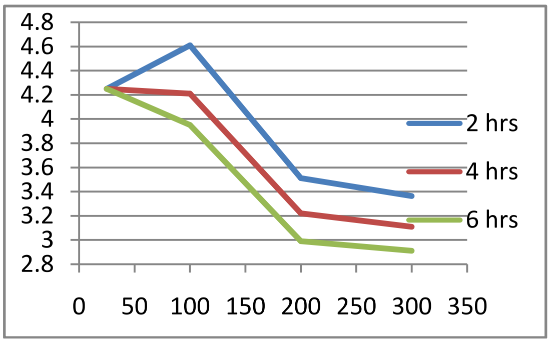
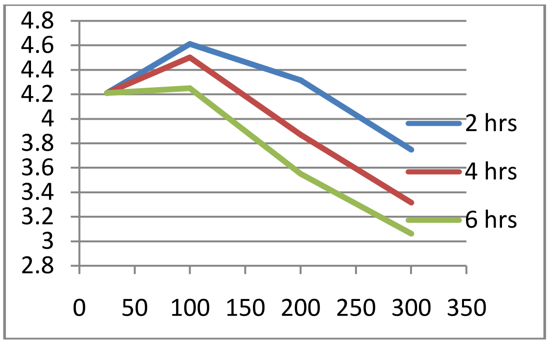
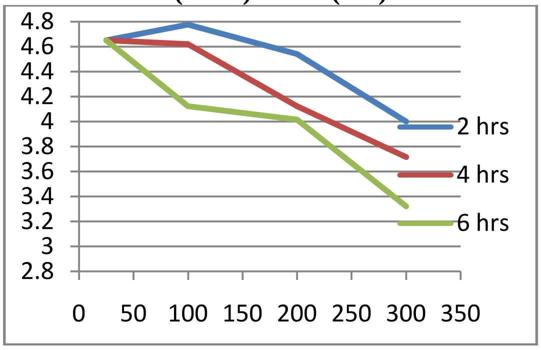


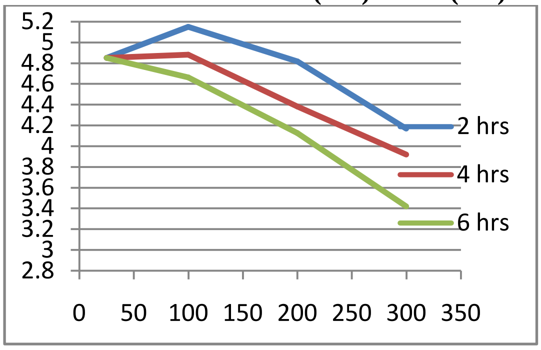
SFRC – VF (0.5%) – Mix (M3)



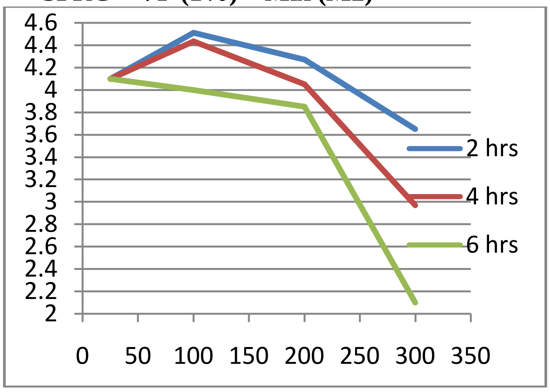
SFRC – VF (1%) – Mix (M1)



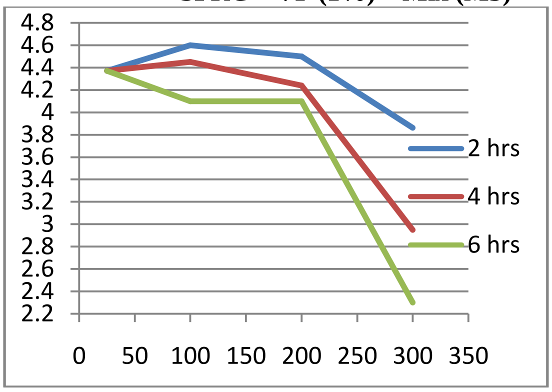
SFRC – VF (1%) – Mix (M2)



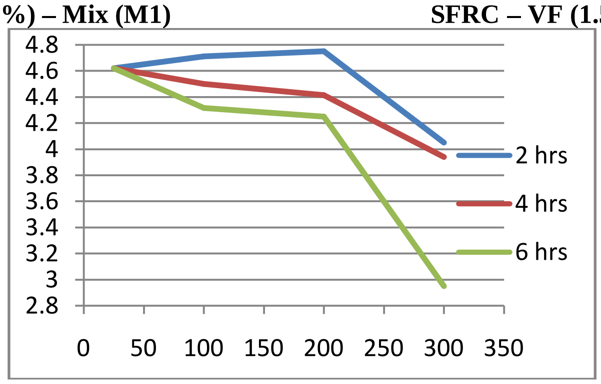
SFRC – VF (1%) – Mix (M3)



SFRC – VF (1.5%) – Mix (M1)



SFRC – VF (1.5%) – Mix (M2)



SFRC – VF (1.5%) – Mix (M3)

Conclusion:

1. Addition of fibers to concrete changes the mode of failure for all tested temperature and there is considerable decrease in strength as the temperature increases above 100^{0}C.At ordinary temperatures the addition of fibers increases the tensile strength ranges from 28.5% to 31.65% for Mix M1,M2 and M3.
2. Exposure to elevated temperature affects concrete strength significantly. The strength decreases depends mainly on the temperature level and the type of concrete. There is a considerable decrease in strength when temperature reaches 300^{0}c for the exposure period of 6hrs.Concrete with & without fibers exhibits tensile stress decreases as the temperature increases.
3. Specimens containing PPF (0.05, 0.1 & 0.15%) the percentage of reduction in splitting tensile strength is lower than that in plain concrete

(without fiber) after exposure to a temperature 100,200 &300^{0}C comparable to normal temperature 25^{0}C.

4. At room temperature addition of steel fiber with (VF) 0.5, 1 &1.5% increase the tensile strength for mix M1 concrete with respect to plain concrete observed as 3.275N/mm² to 3.85N/mm²,4.21N/mm² & 4.10N/mm²respectively.

5. The residual splitting tensile strength f SFRC are higher than that of PPFRC and PC at all tested elevated temperature.

6. The percentage residual strength at 300^{0}c for 6hrs exposure was about 58%-66% for plain concrete and 55% -74.5%for PPF contains 0.05, 0.1 &0.15% in PPFRC, similarly 63% - 71% for SF with VF of 0.5,1 &1.5% in SFRC.

7. Steel fiber increases the tensile strength at all the tested heating levels with maximum percentage of increase of 39.75% at the temperature level 100^{0}c for the exposure period of 2hrs but the residual tensile strength decreases with addition of steel fiber for tested heating level up to 300^{0}c.

8. In all elevated temperature starting from room temperature 100^{0}c,200^{0}c & 300^{0}c for the sustained exposure period of 2hrs,4hrs & 6hrs, PPFRC with VF of 0.05,0.1 &0.15% offers better & improved tensile strength than plain concrete. Similarly SFRC with VF of 0.5, 1&1.5% offers more tensile strength and residual tensile strength than PPFRC and PC.

9. Test result revels that maximum increase in tensile strength observed with addition of 1% of steel fiber into plain concrete at all temperature levels and tensile strength for addition of 1.5% of SF observed was comparatively lower than 1% of SF. Hence test result concludes 1% was Optimum steel fiber content. It was observed that SFRC exhibits more tensile strength than concrete without fiber at all the tested temperature levels.

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